

CHAPTER-3

STUDY AREA

3.1 Overview on the study area

The designation "Korba coalfield (KCF)" was obtained from the geographical location of Korba town inside the Korba district of Chhattisgarh, India. The study area is typically situated within the latitudes of 22°16' 40" N to 22°23' 20" N and longitudes of 82°28' 40" E to 82°43' 20" E, located in the south-central region of the Son-Mahanadi valley which is surrounded by the Korba coalfield. This region is covered by Toposheet number F44K/11 as per survey of India (SOI). Although, mining for coal in the Korba coalfields has started since 1941. The Hasdeo River flows through the southern section, dividing the coalfield into two unequal parts: western and eastern. The power-grade coal reserves in the western sector of the coalfield exhibit significant potential, whereas the eastern portion has undergone limited exploration and possesses a very small coal resource.

This coalfield covers a total area of 530 km² and the total amount of coal reserves in this region are distributed over different depths in the earth. The non-cocking coal reserves were 10,074.77 million tonnes, of which 7,732.87 million tonnes are found up to a depth of 300 m and the remaining 2,341.90 million tonnes are found between 300 and 600 m as per Geological Survey of India (SOI).

It is well linked to motorable roads via Champa township (50 km) and Bilaspur (100 km). The nearest towns to the coalfield are Korba and Champa. The closest railway station is Korba station, located on the Bilaspur-Champa-Korba section of the South Eastern (SE) railway. The Raipur airfield, located at a distance of 275 km, serves as the closest airstrip

to Korba when accessed by road. Additionally, the Bilaspur airstrip is also accessible for smaller planes.

It became practical to mine a large amount of coal from the Korba coalfield after the completion of the Champa-Korba railway line in 1955. The Korba Coalfield is now undergoing open-cast mining operations. The KCF plays a significant role in the coal extraction operations undertaken by South Eastern Coalfields Limited (SECL). The KCF plays a significant role in India's coal production, accounting for around 16% of the country's overall output. Its yearly production is at 117 million tonnes. This area has around seven distinct sub-areas, namely Korba, Surakachhar, Rajgamar, Manikpur, Dhelwadih, Kushumunda, and Gevra. The Korba coalfield encompasses several prominent operational coalmines, namely Surakachhar, Banki, Balgi, Rajgamar, Pavan, Manikpur, Dhewadih, Singhali, Bagdeva, Kusumunda, Laxman, Gevra, and Dipka. The KCF serves as the primary energy provider for a significant proportion of coal-fired thermal power facilities situated within this region. The study area map has been prepared as shown in Fig.3.1 and False colour composite (FCC) of study area has been shown in Fig.3.2. A list of the few thermal power plants using coal from the Gevra and Kushmunda coal mines is as under, along with each plant's capacity.

- Korba super thermal power plant - (2600 MW)
- Thermal power station - (440 MW)
- Dr Shyam Prasad Mukharjee thermal power station (Korba east) - (500 MW)
- Hasdeo thermal power station (Korba West) - 840 MW)
- The captive power plant of BALCO (BCPP) - (270 MW)

The Korba region has been subjected to contamination caused by a range of industries, including opencast mines, smelters, and coal-fired power stations, predominantly

originating from Gevra, Dipka, and Kusmunda. The massive mobility is another factor that contributes to pollution issues (<https://en.wikipedia.org/>).

3.1.1 Gevra opencast mine

The Gevra mine situated in the town of Gevra, holds the distinction of being the second-largest open-cast mine globally, as well as the largest in both India and Asia. It is started in 1981. The Gevra opencast mine was able to produce 35 million tonnes per year in 2011. Approximately 18 million tonnes of coal were produced, and 12 million m³ of overburden were removed between 1999 and 2000. The Gevra mine had a smart plan in 2000 to increase coal productivity from 12 to 25 million tonnes per year. The actual amount of coal production increased from 18 to 26 million tonnes per year during the period of 3.5 years. Based on the SECL report dated March 17, 2007, the Gevra opencast mine achieved a remarkable milestone by extracting almost 1,00,000 tonnes of coal within a single day. This notable accomplishment establishes the Gevra mine as the most significant coal-producing colliery or mine in India to date. The Gevra Mine has been actively pursuing environmental clearance since 2009 in order to expand its yearly capacity from 35 to 43.75 million tonnes. The Gevra opencast mine commenced operations in 1981 under the management of SECL, a subsidiary of Coal India. The company had planned to increase output up to 50 million tonnes in 2016, however the plan has since been abandoned.

3.1.2 Dipka opencast mine

There is an opencast mine site known as the Dipka coal mine located in the Korba coalfield. This mine has an annual capacity of 35 million tonnes per annum (MTPA). The Dipka opencast mine was first managed by SECL, a subsidiary of Coal India. The company was projected to produce an estimated production ranging from 31 to 35 million tonnes in 2018. In September 2018, the mining operations were temporarily suspended

for a duration of one month due to the inundation of the pit caused by the overflow of the Lilagar river. In February 2020, SECL was given permission to prolong the operational lifespan of the mine by an additional 30 years subsequent to the resumption of mining activities.

3.1.3 Kusmunda Opencast mine

There is an opencast mine site in Korba known as the Kusmunda coal mine. SECL began operating the mine for the first time in 1977, and it has an annual capacity of 62.5 million tonnes (MTPA). Since the start of production in 2009, the mining operation has had a rapid expansion in capacity, with an annual output of 10 million tonnes. In 2016, an application was made to get authorization for a capacity expansion from 18 to 26 million tonnes per annum. A few details concerning the open-pit mines at Gevra, Dipka, and Kusmunda are listed in Table.3.1.

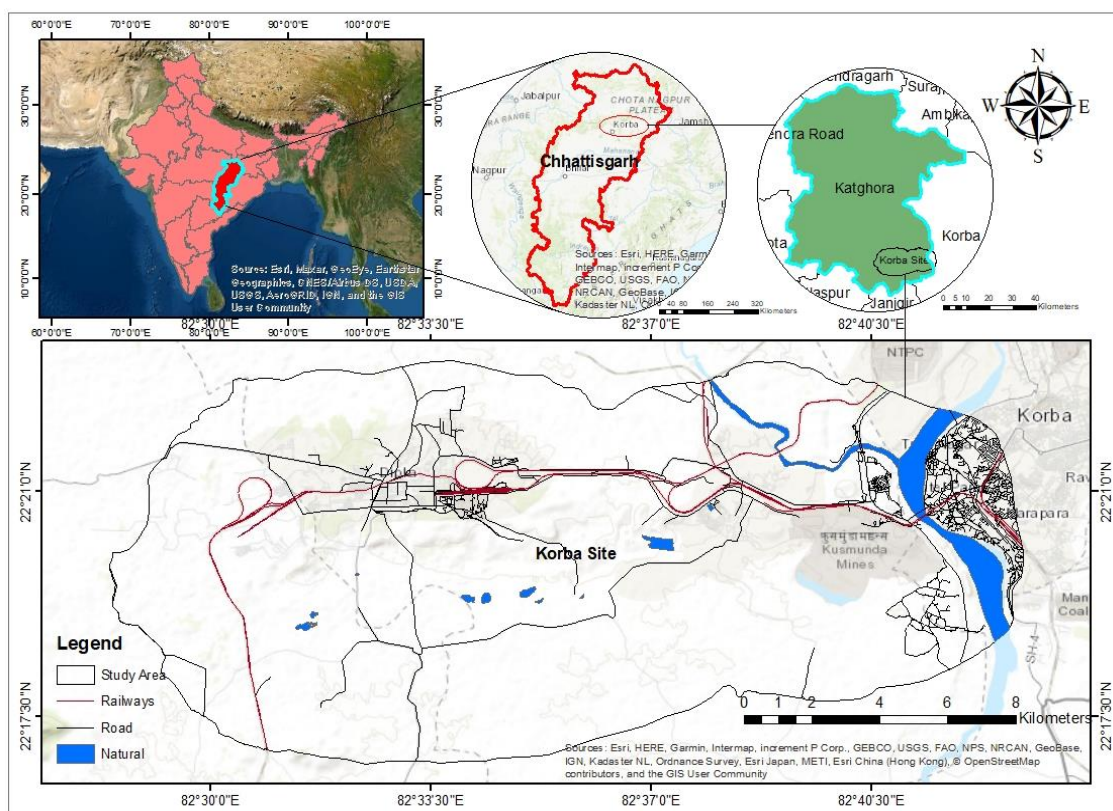


Fig.3.1 Location map of study area

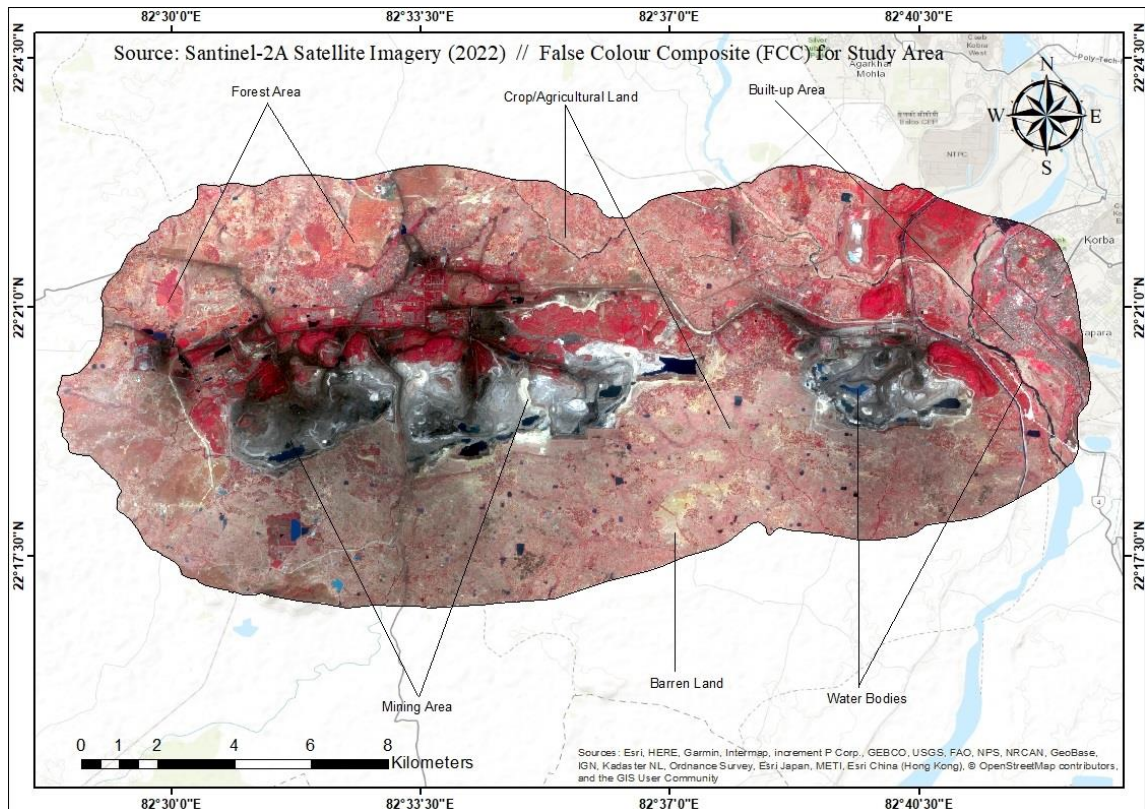


Fig.3.2 False Colour Composite (FCC) of study area

Table.3.1 Mine details for Gevra, Dipka and Kusmunda opencast mine (<https://www.gem.wiki/>)

Mine description	Gevra OCP	Dikpa OCP	Kusmunda OCP
Parent company	Coal India	Coal India	Coal India
Sponsor by	SECL	SECL	SECL
Status	Operating	Operating	Operating
Capacity	41 MTPA	35 MTPA	62.5 MTPA
Reserves	1337.68 MT	975 MT	956.98 MT
Types of coal	Grade D-F	Lignite	Thermal G-11
Size of mine	19.03 km ²	19.03 km ²	14.49864 km ²
Depth of mine	220 m (max)	200 m (max)	300 m (max)
Mining method	opencast	Surface, opencast	Surface, opencast

3.2 Administration information

The study area lied under the toposheet number F44K/11, as per Survey of India is illustrated in Fig.3.3. According to the 2011 census data, the Korba district exhibited a population count of 2,623,082 individuals. Among this population, 643,024 individuals were identified as women, while 1,980,058 individuals were identified as men. Consequently, the district's population accounted for around 1.44% of the overall population of the state. In the decades of 2001 to 2011, the population of the Korba district increased by approximately 19.25 %. In the year 2011, the Korba district comprised a total of 792 villages, exhibiting a population density of 183 individuals per square kilometer (<https://censusindia.gov.in/>). The literacy rate of Korba district is about 72.28 %, which is lower than the national literacy rate of 74.02 %. The literacy rates for men and women are 80.27 % and 60.24 %, respectively. The population growth rate in the Korba district was observed to be 22.51% in 2001, which was comparatively higher than the growth rate of 19.25% recorded in 2011 (<https://korba.gov.in/>).

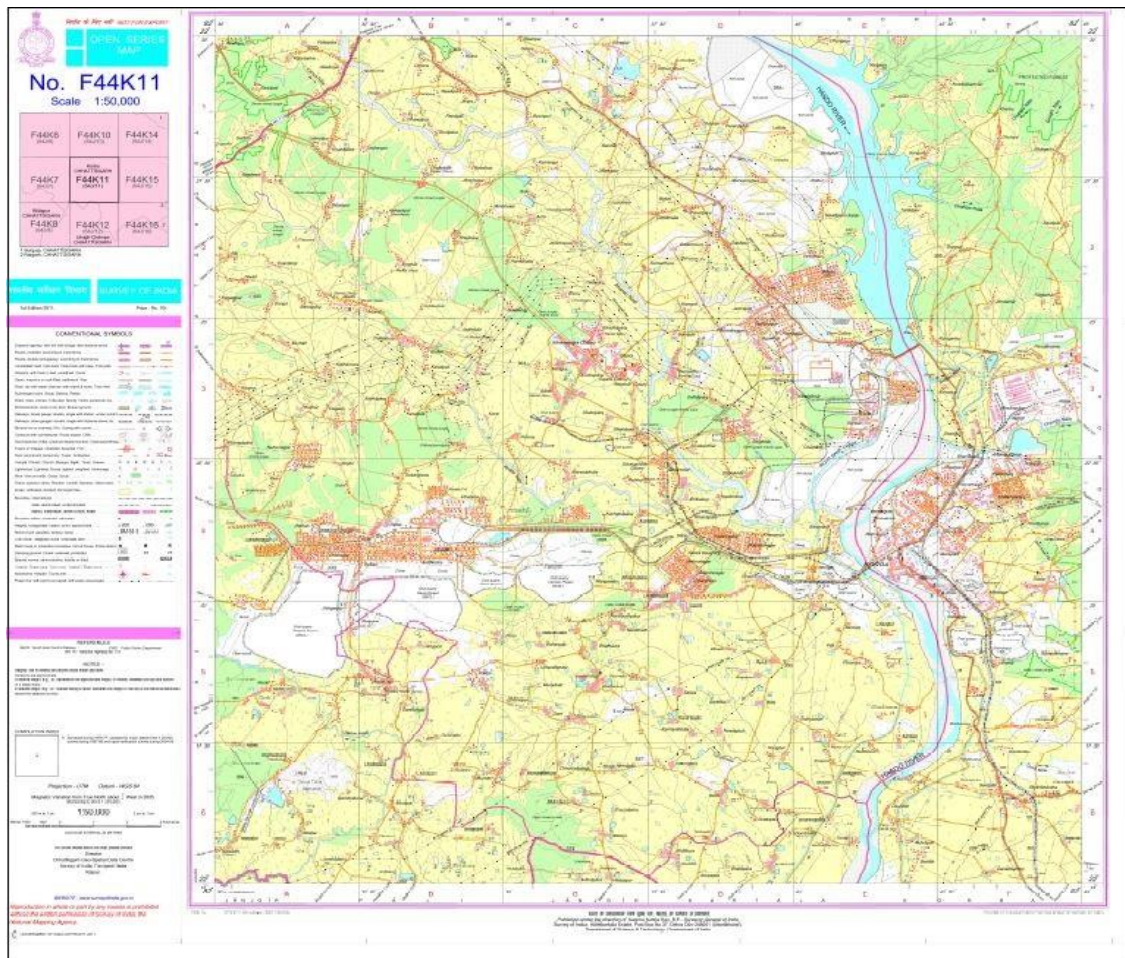


Fig.3.3 Toposheet of study area

3.2.1 Climate detail

The area is characterized by a hot climate zone, exhibiting extremely high temperatures and arid conditions. According to the Koppen-Geiger climate classification, this region falls within the Cwa category (Kottek et al. 2016). The mean annual temperature in the Korba district is estimated to be around 25.61°C, whereas the lowest and highest temperatures recorded during the winter (December-January) and summer (May-June) seasons are approximately 5.18°C and 46.04°C, respectively. The study region experiences the summer months from mid-April to mid-June, followed by the rainy season from mid-June to the end of September, which is attributed to the southwest monsoon.

3.2.2 Rainfall

According to the NASA POWER data, the yearly rainfall over the period spanning from 1981 to 2021 exhibited an average value of 1226.32 mm. Notably, the recorded minimum and maximum rainfall amounts were 764.65 mm and 1671.68 mm, respectively. The rainy season months from June to September received 86% rainfall, while the summer and winter seasons received 10% and 4% of rainfall respectively. This region experiences heavy rainfall since it received rainfall during the south-west monsoon. The rainfall data shows yearly fluctuation as shown in Fig.3.4. The rainfall from 2011 to till 2021 shows increasing patterns as compared to previous decade data. The summer months of March to June exhibit a range of relative humidity from 40.94% to 73.62%, while the rainy months of July to September experience a higher range of relative humidity, ranging from 89.12% to 91.06%. In contrast, the winter months of October to February demonstrate a relative humidity range of 63.69% to 84.94% (<https://power.larc.nasa.gov/>). The region experiences a significant amount of rainfall during the south-west monsoon season.

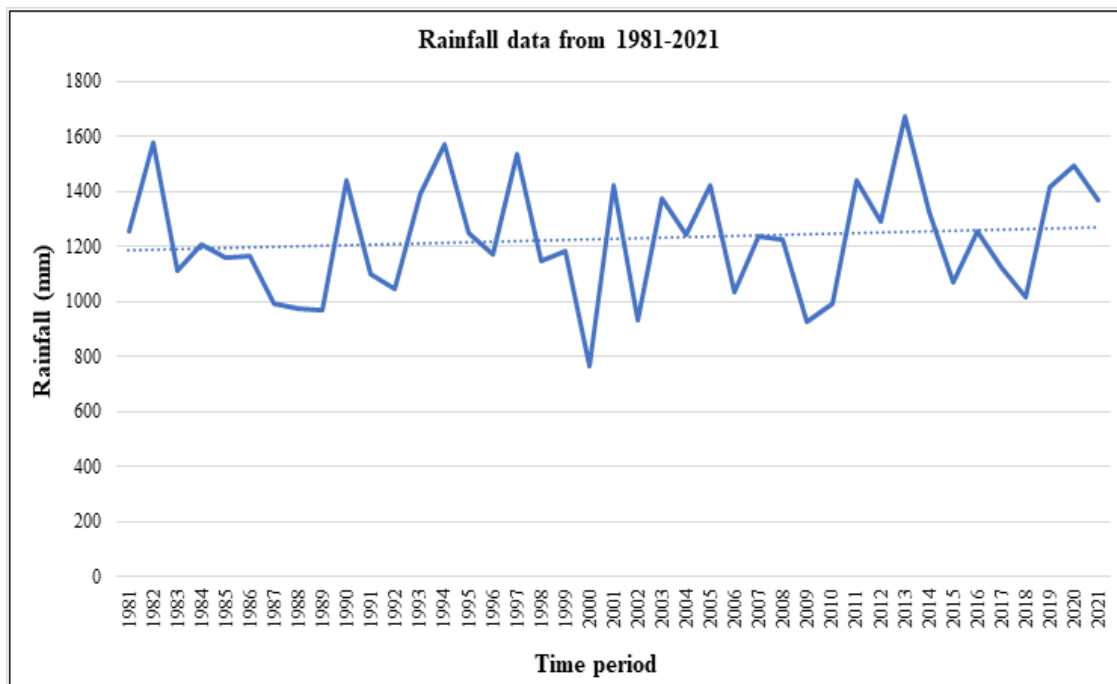


Fig.3.4 Annual average rainfall of study area

3.3. Physiography of the study area

The area exhibits a gently undulating topography that gradually descends towards the south and southeast, aligning with the overall dip of the underlying geological strata. The altitude (reduced levels), exhibits a variation ranging from 425 m in the southwestern portion to 200 m in the eastern section, extending to certain areas within the central region. The main drainage system is Hasdeo River, which runs through the eastern section of the study region. Another significant drainage element that exhibits a southward flow is the ephemeral Lilagar River. In addition to these two rivers, Mand and Ahiran rivers also flow through the study area. The predominant drainage pattern seen in this study area is dendritic in nature. The principal factor responsible for the recharging of dynamic groundwater is rainfall, which serves as the exclusive method for recharging the aquifer (Singh et al. 2017). The KCF has a typical erosional terrain with its plain and plateau topography. The region under consideration exhibits several distinct physiographical features, including dissected plateaus, undulating pediplains, residual hills, intermontane valleys, and valley fill. The western section of the coalfield was split into two distinct sections by the NW-SE trending stream. The pediplain is characterised by the presence of a substantial layer of alluvial soil, which exhibits a range of textures from loamy to sandy (CMPDI Report, 2013).

3.4 Topology and Contour study

The Digital Elevation Map (DEM) file of SRTM data that has been downloaded from the United States Geological Survey (USGS) webpage was used to create the contour map of the study area of the Korba coalfield region, Chhattisgarh. The selected study region is showing gently undulating terrain with elevation ranging from 200 to 425 m. The KCF extended above the surrounding plains, which are covered in the Barakar formation, as a high plateau. According to the study area contour, the coal mining projects were located

on higher land. The contour map (Fig.3.5) reveals that the eastern and certain portions of the central region within the study area (including Korba, Dadar Khurd, Bistrampur, Kosmanda, and Dhurena villages) exhibit relatively lower elevations ranging from 200-275 m in proximity to the Kusbunda and Gevra mines. However, the southeastern, northern, and few parts of the central region exhibit elevations ranging from 276-300 m. The western and north-western regions of the area, encompassing Ratija, Tivarta, Binjhari, Batari, SirdiKhurd, Beltikri, and Ghabar villages, exhibit a moderate elevation ranging from 300-325 m. Conversely, certain portions of the central and southern areas, including Junadih, Mardi, Beltikri, and Newsa village, display higher elevations ranging from 326-375 m. Additionally, the southern side, specifically Newsa village, has a significantly elevated terrain ranging from 376-425 m above mean sea level (MSL). These variations in elevation constitute prominent geomorphological and topographical characteristics within the region.

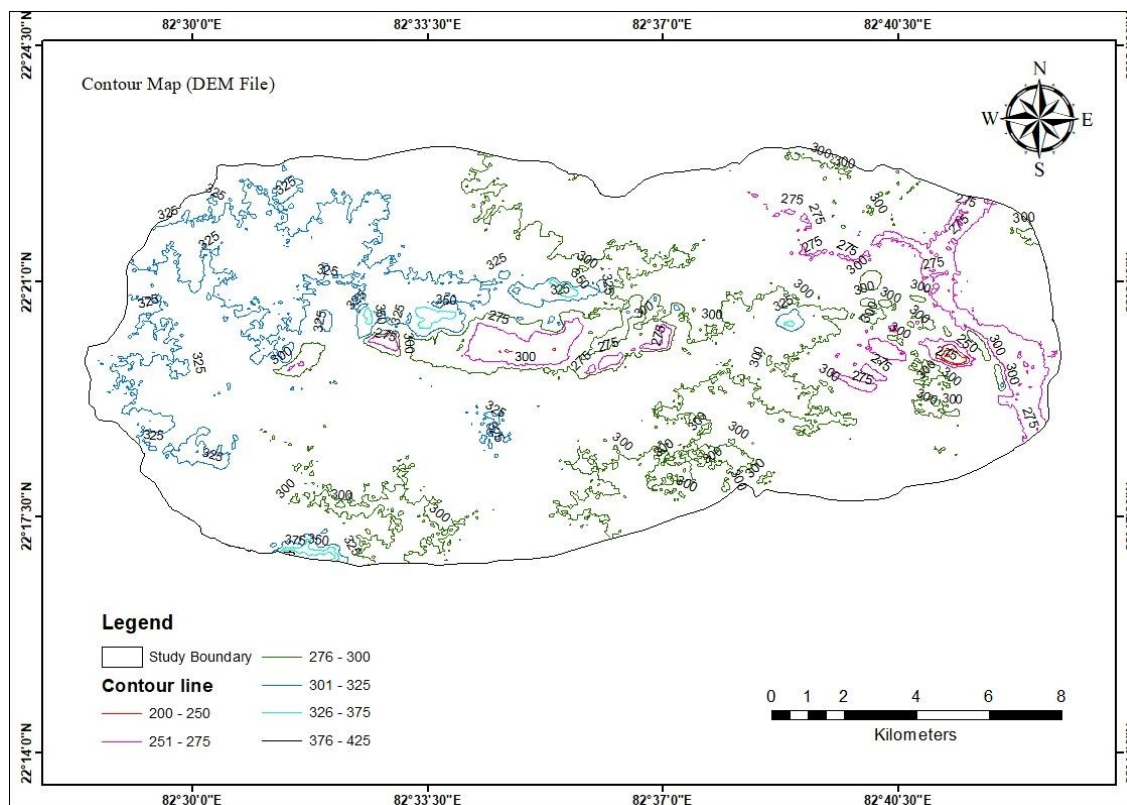


Fig.3.5 Contour map of study area

3.5 Geology of the study area

The geological map for the study region has been created by digitising the geological data using ArcGIS software, which was collected from the BHUKOSH Geological Survey of India (GSI) website (<https://bhukosh.gsi.gov.in/>). Two significant rocks have been identified in this area: undivided Precambrian rocks (pC) and Lower Triassic to Upper Carboniferous sedimentary rocks (TrCs). According to Rao (1983), Barakar formation, a constituent of the Gondwana Supergroup, is located stratigraphically above the Precambrian schist, thereby exhibiting distinctive geological features in the region. The composition of the geological formation consists of Permian-aged coal seams, along with grey shale, carbonaceous shale, coarse-grained arkosic sandstone, and fine-grained laminated sandstone (Table.3.1). The Gondwana rocks of the designated study region are surrounded by Archean rocks on all sides, with the exception of the eastern side. These rocks are composed of the Barakar, Kamthi, Raniganj, and Talchir formations (Fig.3.6).

The orientation of this area throughout its formation is predominantly east-west, with a southern dip ranging from 5° to 8°. Furthermore, the region is characterized by a variety of transverse faults that exhibit orientations in the NE-SW, NW-SE, and E-W directions, while also showing varying throw magnitudes. The coal seams are found exclusively within the Lower and Upper portions of the Barakar Formation, which are separated by a barren zone known as the Middle Barakar. The southern frontier of the coalfield is characterized by faulting, which results in the Upper Barakar formation coming into contact with the basement. In contrast, the northern frontier is un-faulted, and the sedimentary layers rest unconformably on top of the basement. The Barakar formation is overlain by the Kamthi formation, predominantly in the eastern region, exhibiting a disconformity. However, the undulating nature of the basement is evident in the Tarchir

inlier and the basement inside the Barakar formation on the western side (Singh et al. 2017).

Table.3.2 Simplified Chronostratigraphic Succession of the Korba Coalfield, India as per (modified after CMPDIL 2014)

Age	Formations	Thickness	Lithology details
Recent	Alluvium		Soil and sandy soil
Lower Triassic to Upper Permian	Kamthi		Pebby sandstone, Coarse ferruginous sandstone and Conglomerate
Un-Conformity			
Lower Permian	Upper Barakar	350 metres	Varying grain size sandstones, shale, alternate shale, sandstone, carbonaceous shale, sandy shale and coal seam
	Middle	300 metres	Conglomerate and sandstone
	Lower	160-250 metres	Sandstone and shale with thin coal seams
Disconformity			
Lower Permian to Upper carboniferous	Talchir	200 metres	Diamictites, sandstones, needle shales, rythmites, varves and black shale
Late Permian	Raniganj	215-400 metres	Medium to coarse grained sandstone with variegated siltstone and clay
Non-conformity			
Pre-Cambrian	Metamorphic		Granite and Gneiss

3.5.1 Barakar Formation

The study area covers an extensive area of the Barakar Formation in both the east-west and north-south orientations. The Barakar formation holds significant importance within the Gondwana Supergroup of the KCF. The Barakar formation, which is found in the Lower Permian period, is characterised by the presence of three distinct layers known as

the Upper Barakar, Middle Barakar, and Lower Barakar. The upper Barakar layers consist of shale, sandstones with varying grain sizes, transitional shale, carbonaceous shale, sandy shale, and coal seam. On the other hand, the intermediate and lower Barakar strata are characterized by conglomerate, sandstone, and shale with thin coal seams. The Barakar formation exhibited a total thickness ranging from 160 to 350 metres, comprising several layers known as the top Barakar (350 m), the medium Barakar (300 m), and the lower Barakar (160-250 m). Furthermore, this formation is composed of 68 % of sandstone, 26 % of coal, and rest 6% of shale. Three major projects, namely Gevra OCP, Dipka OCP, and Kushmunda OCP, predominantly lie beneath the Barakar Formation and are classified as part of the Gondwana Formation Supergroup.

3.5.2 Talchir Formation

The Tarchir formation is followed by the Barakar formation, which is situated in the north-western region of the KCF. The Tarchir formation is categorized as having an age ranging from the Lower Permian to the upper Carboniferous, and it is a constituent of the Gondwana Supergroup. This formation can be distinguished by the alternating patterns of coal seams, massive sandstone with medium to coarse grains, carbonaceous shale, and, on occasion, clay lenses. The Talchir formation, which extends from the lower Permian to the upper Carboniferous, exhibits lithological features such as diamictites, sandstones, needle shales, rythmites, varves, and black shale. The total thickness of the Talchir formation measures 200 m.

3.5.3 Raniganj Formation

The Raniganj formation is located in the northeastern region of the KCF and is classified as Late Permian in age, belonging to the Gondwana Supergroup. The total thickness of this this formation ranged 215-400 m. It is very close to Kushmunda mine. The

lithological properties of the Raniganj formation consist of medium to coarse grained sandstone, together with variegated siltstone and clay.

3.5.4 Kamthi Formation

The Kamthi formation is situated in the eastern portion of the KCF region and is characterized by its lower Triassic to upper Permian age, making it a constituent of the Gondwana Supergroup. A large part of the east side of Manikpur OCP and Korba city was covered by the Kamthi Formation. The lithological characteristics of the Kamthi Formation include pebbly sandstone, coarse ferruginous sandstone, and conglomerate.

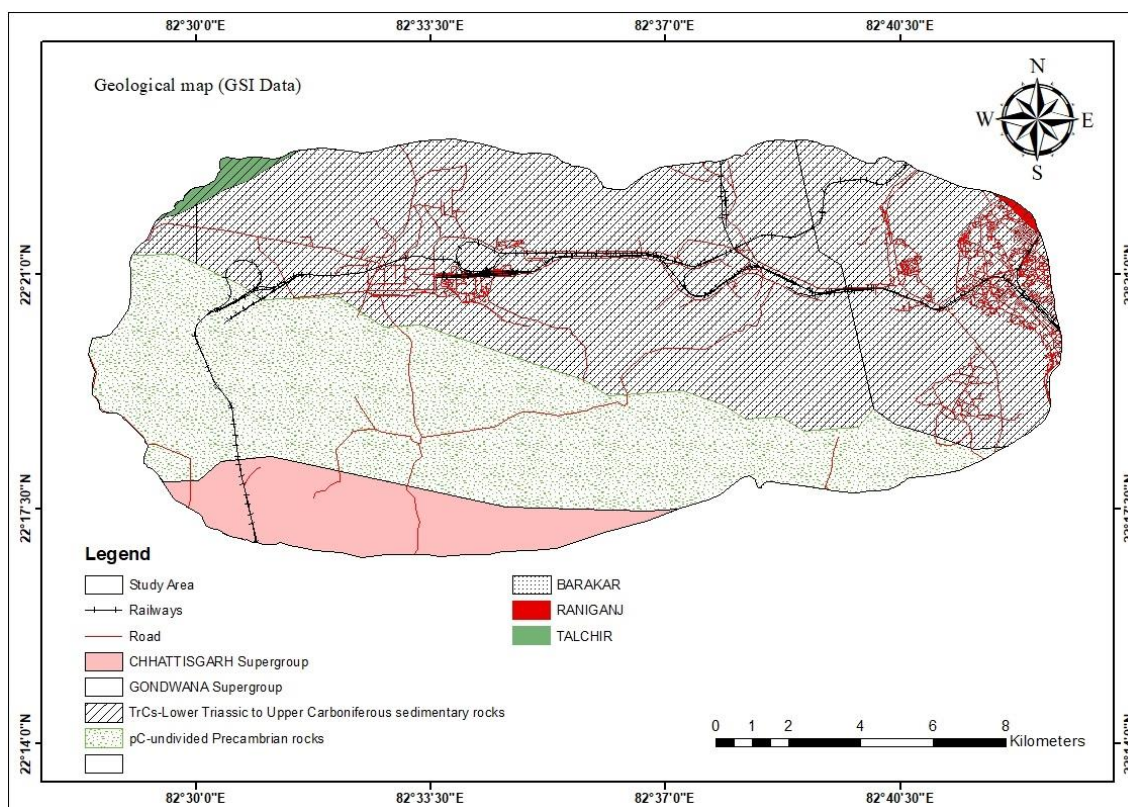


Fig.3.6 Geological map of the study area

3.6 Geomorphological details of the study area

The geomorphological map of the study area has been prepared by digitising the geomorphological information on ArcGIS, taken from the BHUKOSH GSI website (<https://bhukosh.gsi.gov.in/>). Several significant geomorphological units have been

identified, encompassing features such as low dissected denudational hills and valleys, low-lying flats within the Pediment and Pediplain Complex, active flood plains, active quarries, abandoned quarries, mining waste areas, and bodies of water is shown in Fig.3.7. The study area consisted of a low dissected denudational hill and valley in the southwest corner, while the Pediment & Pediplain complex was predominantly located in the east-west and north-south region. The structure was formed by the presence of resistant upper Carboniferous sedimentary rock and Precambrian rocks. The anthropogenic activities are reflected in the central region by an active quarry and a mine dumps.

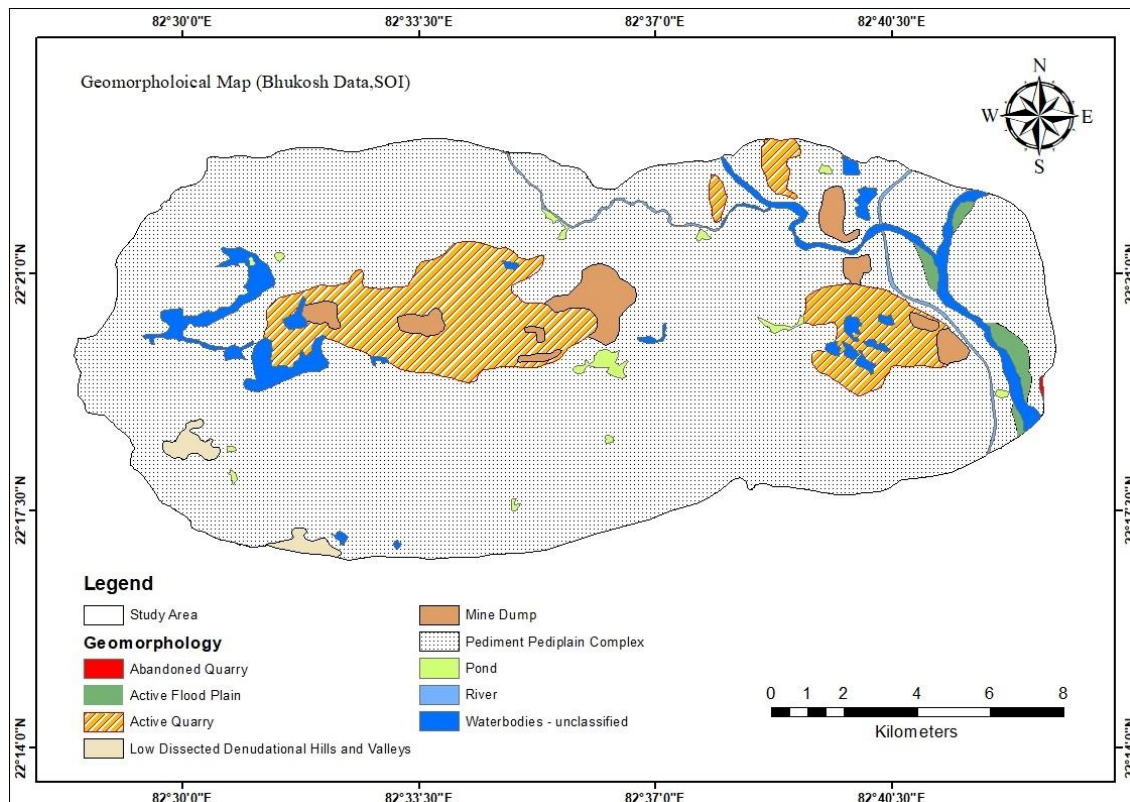


Fig.3.7 Geomorphological map of study area

3.7 Drainage pattern of the study area

The USGS DEM file of SRTM (Shuttle Radar Topography Mission) data was used to digitize the drainage map in ArcGIS. The formation of drainage patterns in a given drainage basin is typically attributed to the presence of streams, rivers, and lakes. The configuration of drainage patterns is influenced by various factors, including geographical

features, the composition of underlying rock formations, and the slope of the terrain. The geomorphologists and hydrologists often include streams in drainage basins and sub-basins. The drainage pattern is described as dendritic in nature (Fig.3.8), generated and regulated by both lithology and topology of the area. The Hasdeo, Lilagarh, Ahiran and Mand rivers, are the major river streams, flow close to the KCF region. The Hasdeo Bango is a dam constructed across the Hasdeo River, serving as the primary source of irrigation water for the agricultural activities in the surrounding region. There are two another stream called Kholar and Dhengur Nala are existing in that region.

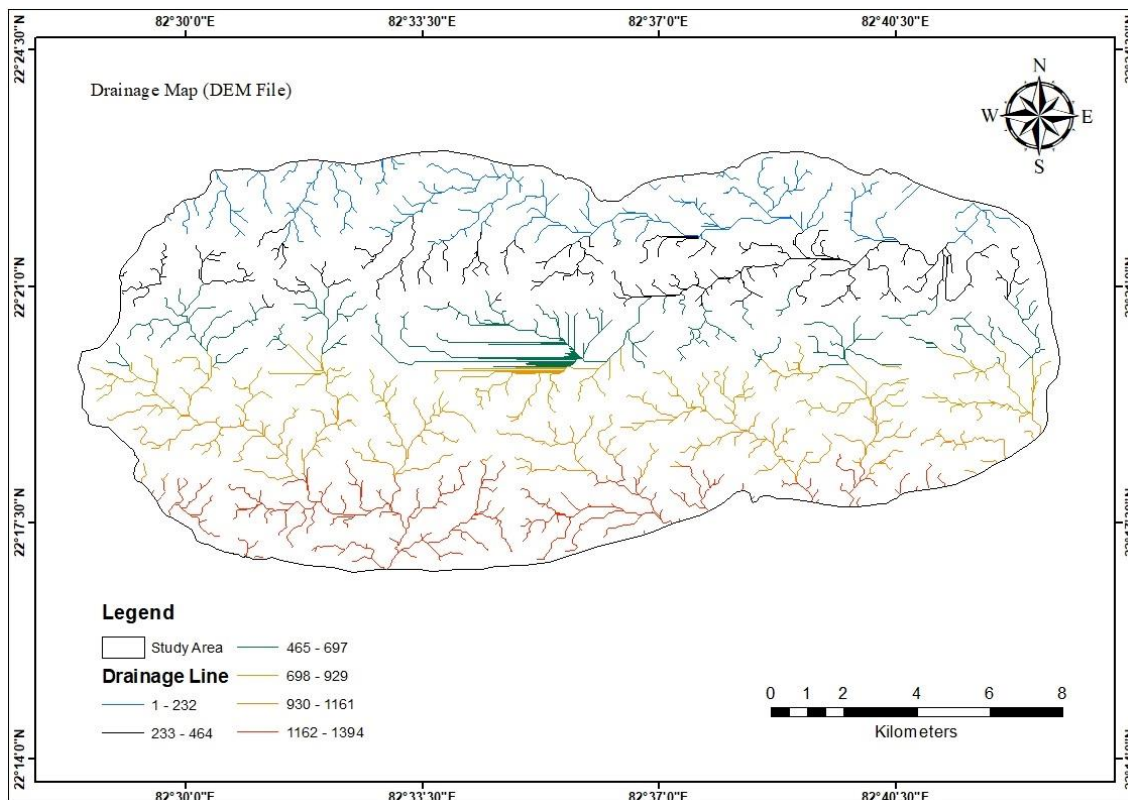


Fig.3.8 Drainage map of study area

3.8 Hydrogeological feature of the study area

The study region encompasses various geological formations, namely the Barakar, Raniganj, and Talchir formations, which display a variety of aquifer characteristics. The groundwater occurrence and flow vary with rock type for distinct formations. The hydrogeological characteristics of the study area pertain to the upper Barakar formation,

encompassing carbonaceous shale, arkosic sandstone exhibiting varying grain sizes, interspersed with shale beds and substantial coal seams, which predominantly occupy the region. The upper strata of the Barakar formation have porous sandstone beds that are saturated with water, which together create a possible aquifer that has appropriate transmissivity (T). The aquifer mostly consists of permeable sandstone, with adjacent shale beds and coal seams serving as impermeable layers, known as aquicludes. The aquifer system in the region is characterized by the presence of sandstone beds between coal seams and the shale that is associated with them. This presence of sandstone beds between coal seams and shale leads to the prevalence of a multi-layered aquifer system, which is mostly due to stratification. The alluvium and sandstone formations can be referred to as superficial deposits, primarily located above the active coal seams. These deposits typically have an average thickness of around ~50.0 m and function as an unconfined aquifer. On the other hand, semi-confined or confined aquifers can be found in the lower layers, which are primarily composed of dense sandstone with secondary porosity (CGWB 2012). The groundwater table is approximately horizontal with 1.2×10^{-2} gradient which sloping more toward the S or SE in the area (Singh et al. 2016; 2017).

3.9 Lineament study

The Lineament map for the area is generated by digitising geomorphological data using ArcGIS software, acquired from BHUVAN-NRSC (National Remote Sensing Centre) website (<https://bhuvan.nrsc.gov.in/>). Lineament is characterized by the presence of fracture zones, fissures, and faults beneath the Earth's surface. These geological features play a crucial role in the storage and movement of groundwater in regions with hard rock topography. The formations in this region exhibit an east-west orientation, accompanied with a southern inclination ranging from 5° to 8° . The E-W trending fault in the region that has a southerly throw is notable because it lies in juxtaposition to the upper and lower

Barakar formations in the northern portion of the area. This fault divides the lower Barakar (up thrown) and upper Barakar (down thrown) formations, which may disappear or have little throw near the Hasdeo River (Singh et al. 2017). The Lineament map for the KCF area is shown in Fig.3.9.

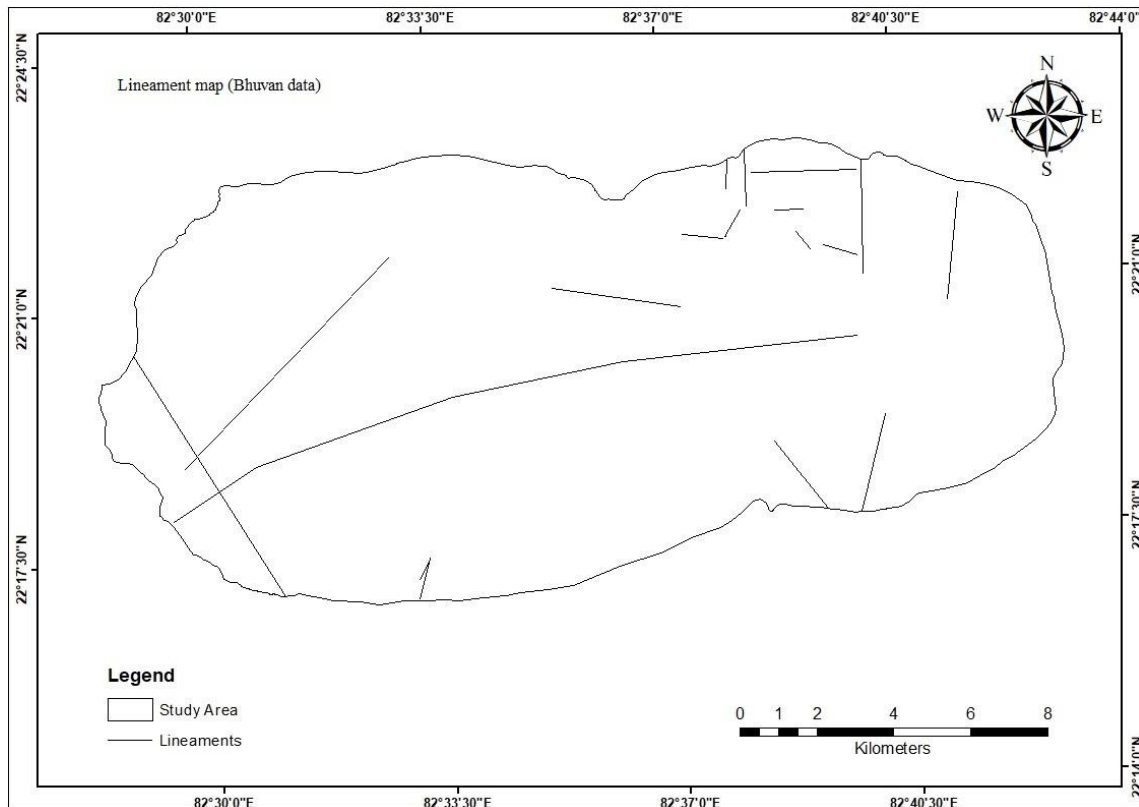


Fig.3.9 Lineament map of the study area

3.10 Flora and Fauna

The social and economic structure of Korba is significantly influenced by its forests. This region has huge forest wealth. Korba and Katghora are the two forest divisions of the Korba district. The Korba district encompasses three primary categories of forests, namely protected forests, unclassified forests, and revenue forests. The main categories of tree species include Sal, Teak, and a mixed deciduous variety. Additionally, there are other important species such as Bija, Saja, Dhavdha, Mahua, Tendu, and Bamboo etc. it can be observed from topological analysis that there exists a variation in vegetation density, with valleys exhibiting a significantly higher density in comparison to hills.

Approximately 68% of the population in the Korba district is involved in agricultural activities, indicating that the district is predominantly characterised by its agricultural sector. Paddy is the primary agricultural crop cultivated in rain-fed regions. The Korba district has a few notable wildlife species such as tigers, bears, and elephants etc. The industrialization, massive mining activities, and deforestation are the main threats to biodiversity and wildlife. The fauna experienced a gradual decline and move to more remote areas over time.

3.11 Soil characteristics of the study area

There is relatively limited soil cover on the plateau. The Pediplain exhibits a variation in soil texture within a variety of loamy to sandy, characterized by its thick alluvial composition. The Korba district encompasses a diverse range of soil compositions. The yellowish to reddish Alfisols (Red gravelly, red sandy, and red loamy) were made by the weathering of crystalline and metamorphic rocks which covered over 83% of the district. Approximately 14% of the district's territory in the north and east sides are covered by Ultisols (Lateritic soil, red and yellow soil) in the form of laterite. The rest of the district, including small parts of Pondi Upendra block, is covered with light grey and shallow black inceptisols. The Inceptisols are soils that have relatively new origin (CGWB, 2013).

3.12. Slope Study

The slope map of the study area was created using a DEM file using SRTM data downloaded from the USGS website. The slope was classified as gentle (0° - 4.24°), moderate (4.25° - 14.03°), steep (14.04° - 39.16°), and extremely steep ($>39.17^{\circ}$) as given in Fig.3.10. From this slope map, it can be found that majority of north and south landscape of the area has a gentle slope (0° - 4.24°), while the east, west, south west corner, and central area have a moderate slope (4.25° - 14.03°). Whereas in the south west corner along with an east to west area are covered by a steep (14.04° - 39.16°) slope,

however no areas come under very steep slope ($>39.17^\circ$). The presence of overburden dumps in mining areas often results in the formation of steep slopes. The coal mining projects are situated on high ground in the study area.

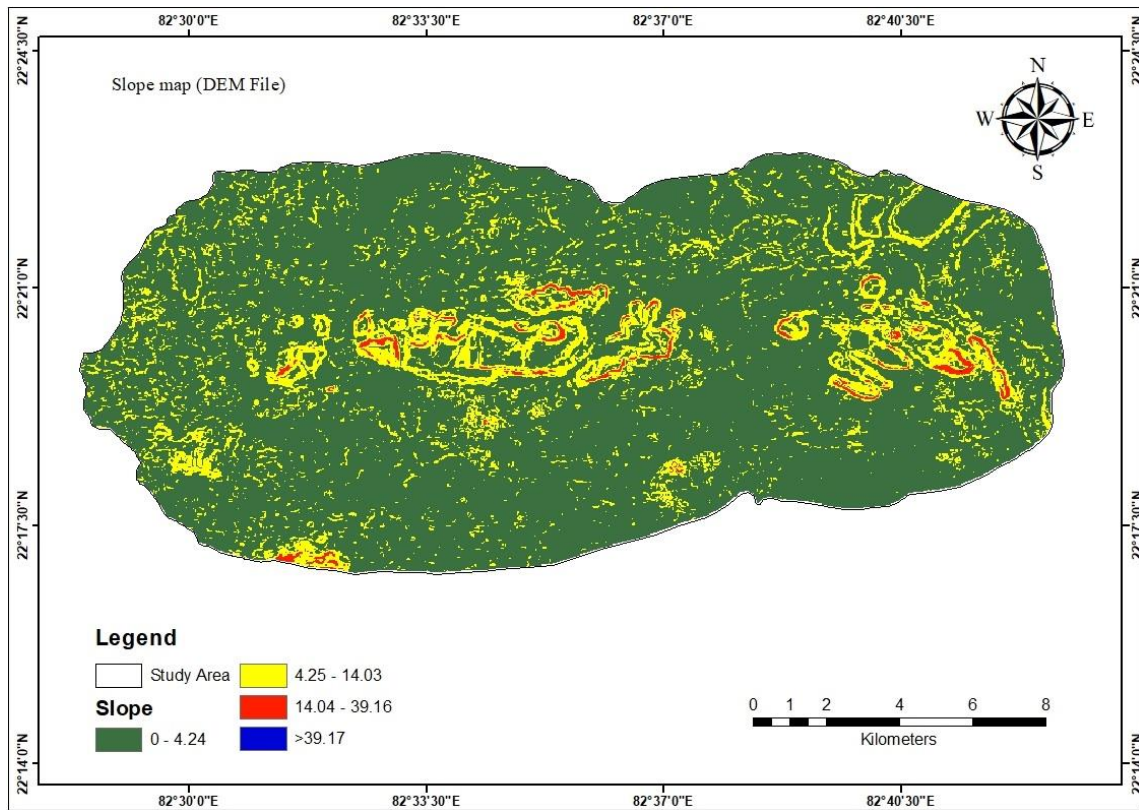


Fig.3.10 Slope map of study area